Olivine reveals a shift in mantle fertility, coincident with rifting and the onset of rhyolitic volcanism in the Taupo Volcanic Zone, New Zealand.

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Understanding the driving forces behind shifts from normal andesitic arc-type eruptive style to hyper-productive silicic volcanism is one of the most fundamental aspects of geology. The central Taupo Volcanic Zone (TVZ) in New Zealand, the most productive of silicic volcanic centres, is flanked by younger andesitic stratovolcanoes to the south, which are regarded as precursory to rhyolitic volcanism, making the TVZ an ideal place to study driving forces behind the shift in eruptive style. Small basaltic scoria cones occur along the length of the TVZ, and compositions co-vary with the andesite-rhyolite shift. The most primitive of these basalts contain abundant xenocrysts, giving insight into the mantle feeding the TVZ.

Here, we use olivine composition to separate magmatic processes from primary mantle signatures. Xenocrysts from the central TVZ are lherzolite-derived, whereas xenocrysts from the south TVZ are harzburgite-derived, providing the first evidence for a shift in mantle fertility coincident with the shift from andesitic to rhyolitic activity. This implies a direct link between rifting, source composition and volcanic productivity. Diluted arc signatures in trace elements from the central TVZ, compared to enrichments in the north and south TVZ, show that subduction-derived fluids promote mantle melting, but it is ultimately the extent of rifting that controls mantle lithology, and therefore volcanic productivity. The central TVZ is testament to the effect that lithospheric thinning can have on volcanic activity, producing large-volume melts from flux melting and adiabatic decompression of fertile lherzolite mantle, driving the extraordinary productivity of the region.